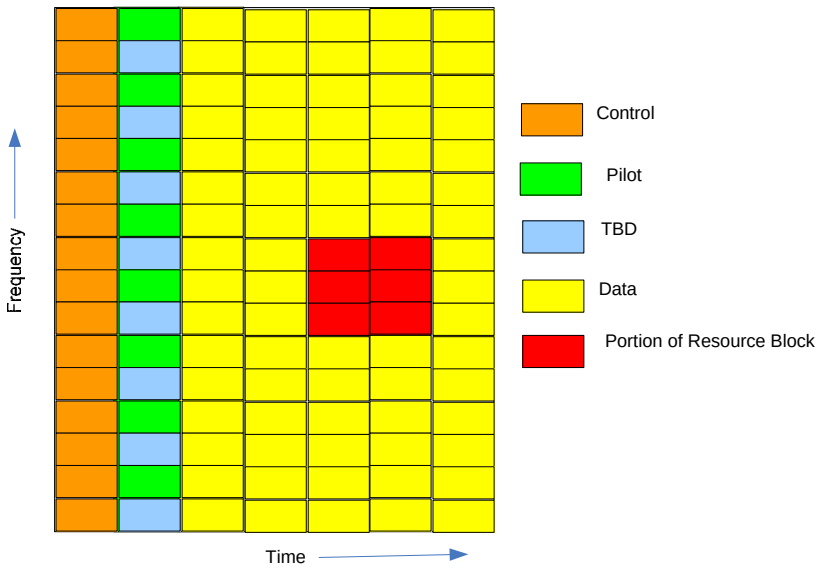
R2-060120 Physical Layer Overview and L1/L2 Interface Design Drivers

Motorola

Agenda Item 6.1

Overview of LTE Physical Layer

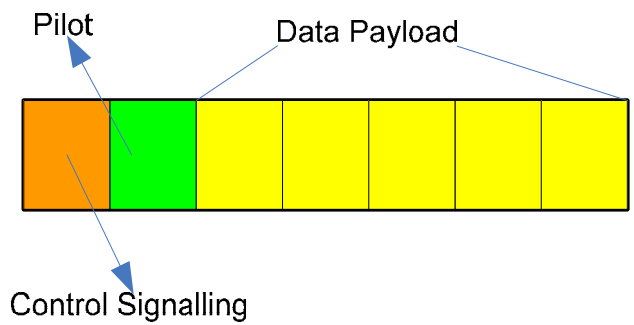
Frames, Physical Channels and Resource Blocks



- LTE carrier (5 MHz, 10 MHz, etc.) consists of many physical channels – common and shared
- Physical Resources consist of Frequency/Time symbols
- Frequency space consists of multiple equally spaced sub-carriers
- A Resource Block (RB ☹) consists of "M" number of consecutive sub-carriers over "N" number of consecutive symbols. A UE may not be assigned every sub-carrier in a resource block – it could be assigned every Qth sub-carrier of a resource block. In the slides that follow the set of resources that are assigned to a UE is called Resource Assignment. Thus a Resource Assignment can be a Resource Block or a fraction of it; more generally a Resource Assignment is a fraction of multiple Resource Blocks.

Sub-Frame Design - Downlink

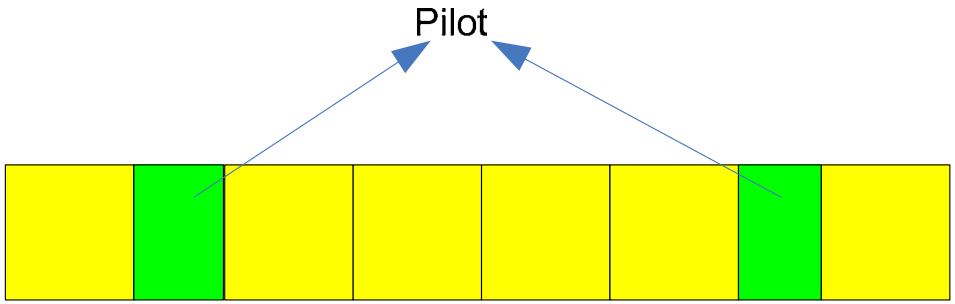
Downlink Sub-frame Structure



- **Possibility to have additional pilot symbols for high Doppler**
- **Pilot Symbol in every Nth sub-carrier**
- **Control Signaling and associated pilot located within first two symbols to assist with micro-sleep**
- **Additional symbols used for Synchronization, etc.**
- **Effectively at least 5 symbols available for data**
  - **Can also be used for additional control signaling**

Sub-Frame Design - Uplink

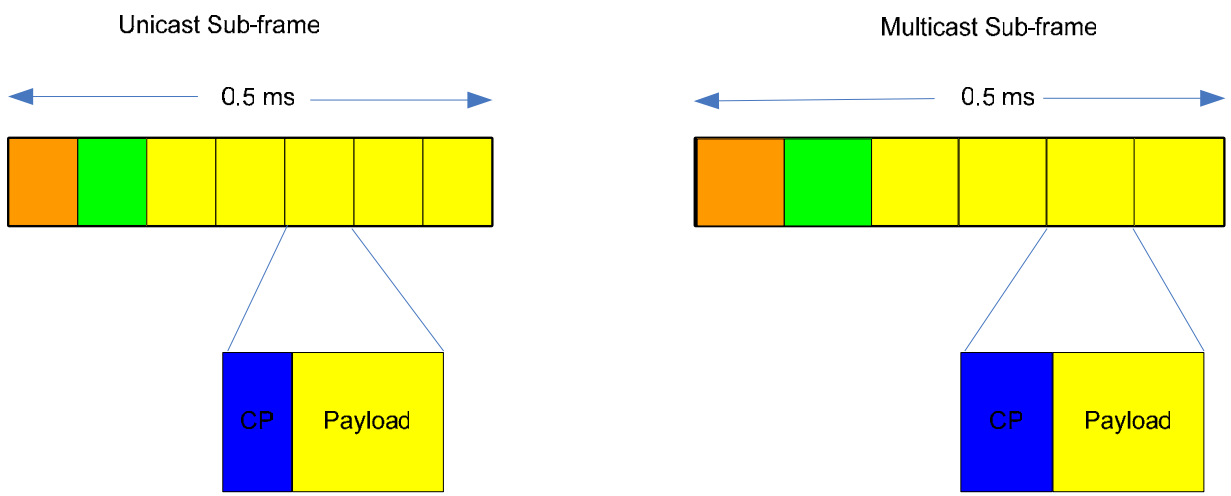
Uplink Sub-frame Structure



- **Split Pilot Symbol to facilitate good channel estimation at higher speeds with lower overhead**
- **Data dependent or data independent control information may be provided along with data (CQI, TFI etc.) – FFS.**

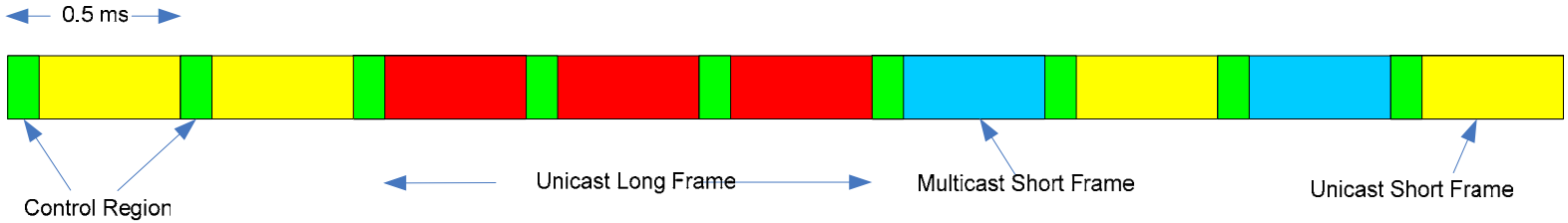
Broadcast/Multicast Sub-frame

- **Requirements of broadcast/multicast requirements lead to a different Layer 1 subframe structure for multicast compared to unicast**
- **Use longer cyclic prefix (CP) length for broadcast/multicast SFN, and possibly larger cells**
  - **Subframe duration is identical for both subframe types to facilitate multiplexing of services**



Radio Frame Structure

- **Radio Frame of 10 ms**
  - **Consists of integer number of subframes**
    - A TTI may equal the duration of a short frame (1 subframe duration) or a long frame (several subframes, e.g. 2 ms)
  - **Synchronization symbols could be spread over one Radio Frame or assigned to first subframe of Radio frame**
    - For cell search and initial synch
    - 10 ms time duration potentially helpful in case of time-synchronized UMTS and LTE systems for e.g.
  - **Remaining symbols used for pilot, control and data**
  - **Potentially inter-mix broadcast/multicast and unicast frames in one Radio Frame**
    - A subframe is either of unicast or broadcast/multicast type but does not support both
  - **Common control channels time-division multiplexed into subframe sequence**
    - Broadcast channel, Paging channel, Synchronization channel



Primary Drivers for L1-L2 Design – what do we need/want to support on radio for scheduling?

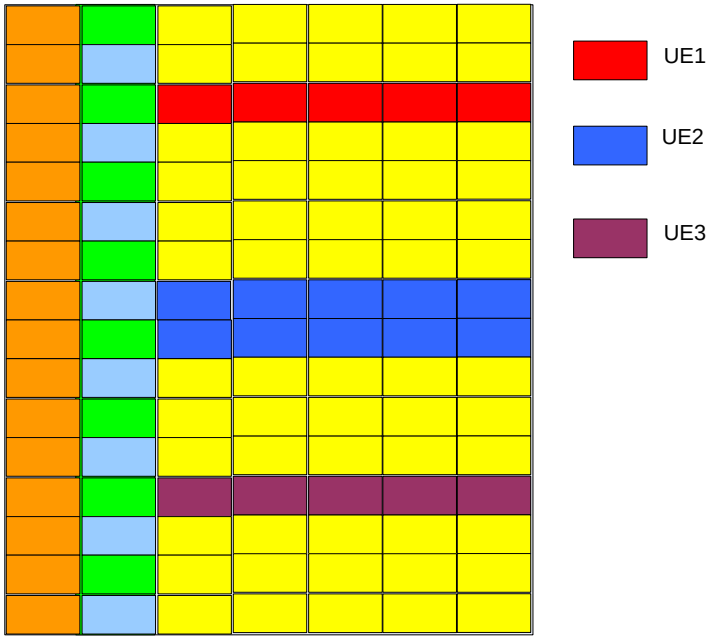
Primary Drivers for L1-L2 Interface Design

- **Efficient Scheduling Enablers that support**
  - **Low Latency**
  - **High Spectral Efficiency**
    - Minimal control signaling requirements including feedback while still meeting QoS requirements
  - **Ability to serve wide variety of services (voice, data, multimedia, unicast, multicast…)**
    - Flexibility

Scheduling

- **Frequency Diverse**
  - **Useful for allocations when reliance on CQI feedback is to be minimal or feedback not available or reliable**
  - **UE multiplexing**
    - Single UE
      - Assign all resources within one frame (short/long) to one user
        - » More applicable in uplink
        - » Applicable in downlink for large packets
    - Multiple UEs
      - Divvy up resources among multiple users
  - **Short/Long Frame allocations**
    - Short frame or long frame allocations are possible based on traffic characteristics, service mix, latency and overhead.
- **Frequency Selective**
  - **Typically Multiple users within a TTI assigned to different sub-carriers**
  - **Can be using Short or Long frame**
    - Long frame also useful for small packets to exploit temporal coherence while offering improved band payload, as opposed to fitting packet into one short frame using FD allocation that may not be optimal

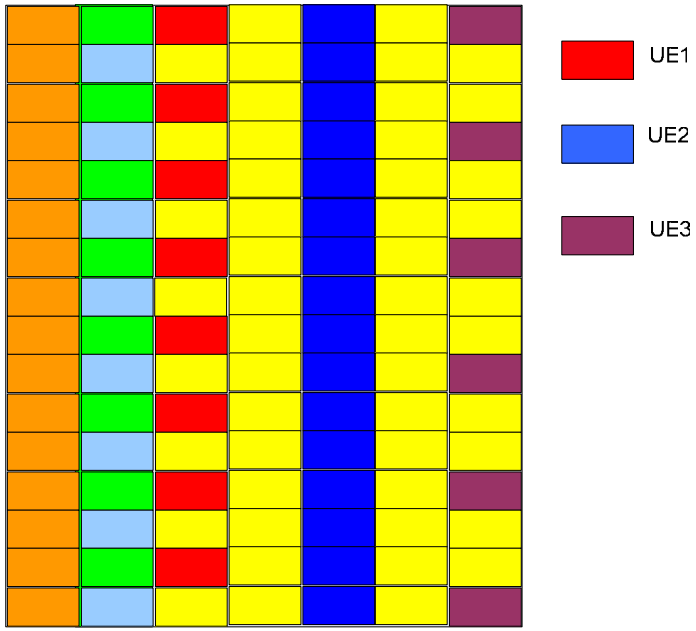
Short Frames – Frequency Selective Allocation



- **Frequency Selective Allocation**
  - **Based on CQI feedback**
  - **Allocation may be Resource Block based**
    - Preferable to have total usable bandwidth divisible into integer number of same-sized Resource Blocks

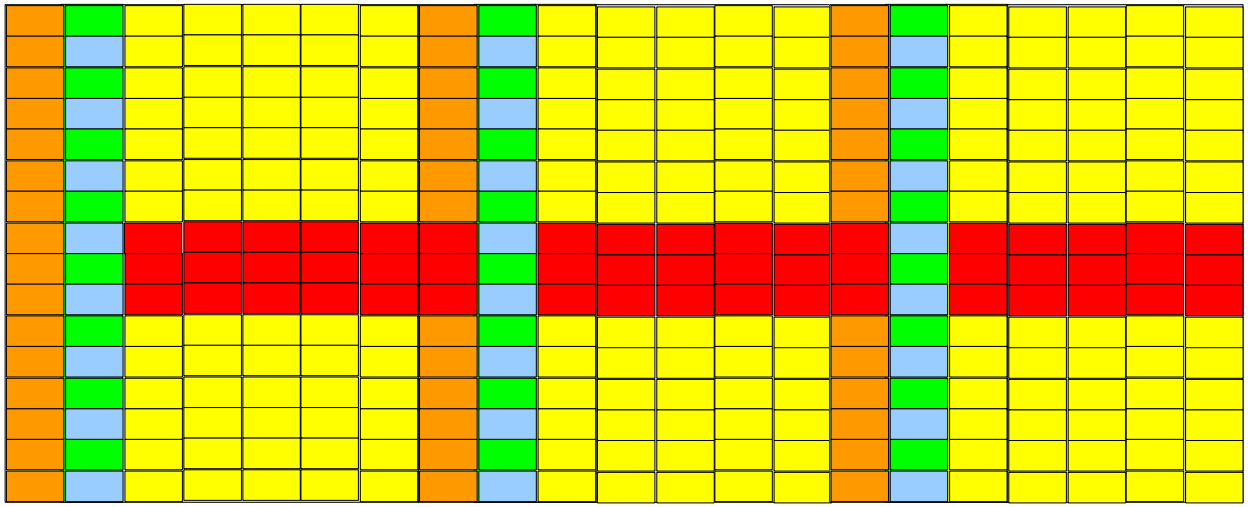
Note: It might be useful to standardize a minimum sized assignment to a UE, e.g. 375 kHz, in Frequency domain. The figure to the left is for illustration purposes only.

Short Frames – Frequency Diverse Allocation



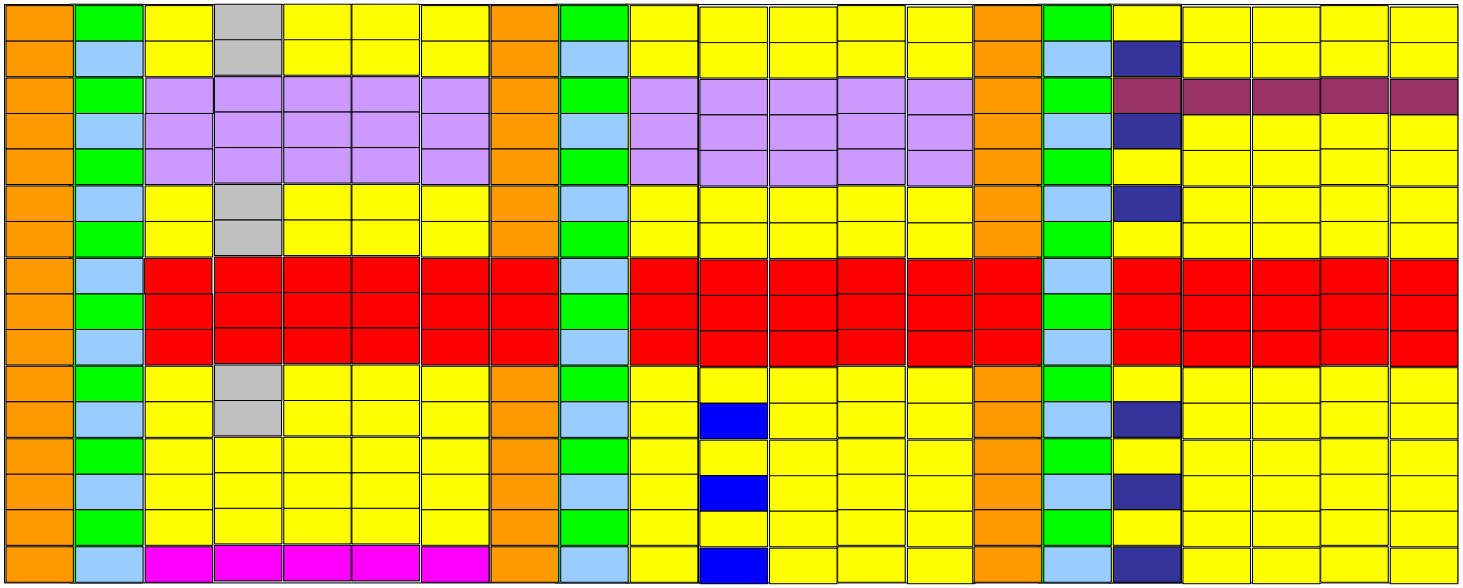
- **Frequency Diverse Allocation**
  - **Can be contiguous or non-contiguous (UE is assigned every Qth sub-carrier of Resource Block)**
  - **Can be viewed as puncturing Resource Block Allocations when co-existing with Resource Block based scheduling**

Long Frame Allocation



- **Efficient frame structure for:**
  - Edge of cell operation
  - Large packet delivery (potential control efficiency)
  - Multi-user and frequency-selective scheduling (improved band payload)
- **Long frame Frequency Selective transmission**
  - Control region in 2nd and 3rd sub-frames used for data (FFS)
  - Useful even for small packets to exploit frequency selectivity

Short/Long Frame Combinations



UE 1 Single Frame FD Allocation

UE2 Long Frame FS Allocation

UE3 Single Frame FD Allocation

UE4 Single Frame FS Allocation

UE5 Long Frame FS Allocation

UE6 Single Frame FD Allocation

UE7 Single Frame FS Allocation

- **Overall there is a wide variety of possibilities that might need to be supported through the L1-L2 interface to accommodate different traffic characteristics and load situations**
- **It is possible to define the same sub-frames to be either Short or Long frames across UEs and even for one UE.**